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Seasonal Habitat Use and Movements Of Transplanted and Source Herd Stone's Sheep, Peace Arm of Williston Reservoir (1990-1994)

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PWFWCP Report No. 226

The Peace/Williston Fish & Wildlife Compensation Program is a cooperative venture of BC Hydro and the provincial fish and wildlife management agencies, supported by funding from BC Hydro. The Program was established to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett and Peace Canyon dams on the Peace River, and the subsequent creation of the Williston and Dinosaur Reservoirs.

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EXECUTIVE SUMMARY

The creation of Williston Reservoir in the late 1960's resulted in the isolation of vacant Stone's sheep habitat south of the Peace Arm. The Peace/Williston Fish and Wildlife Compensation Program initiated the Mount Frank Roy/Mount Monteith Stone's sheep transplant in order to establish a population south of the reservoir. A radio-telemetry study was implemented to identify and compare seasonal ranges, movements, and habitat use of the source herd, north of the Peace Arm, and the transplant population. A total of 28 Stone's sheep were successfully transplanted over a 3-year period. Four radio-collars were fitted on sheep in the source herd and 10 sheep were collared in the transplant herd. Radio-telemetry flights were conducted on a monthly basis from January 1990 through May 1994.

The study identifies 3 distinct winter range preferences in the source population, but is inconclusive on the success of the transplant. Management recommendations and research requirements include:

- Detailed inventory of the 3 identified winter habitats north of Williston Reservoir.
- Analysis of winter diets and forage availability for both the source and transplant herds.
- Development of a long-term prescribed burning program for enhancement and maintenance of winter ranges.

This report was originally submitted in July 1994. A revised version was completed May 2000, incorporating comments from a review panel of B.C. Environment and B.C. Hydro wildlife biologists.

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1.0 INTRODUCTION

The Peace River valley marks the southern limit of Stone's sheep range in B.C. Some suitable habitat exists south of the Peace River, however the creation of the Williston Reservoir isolated this area from the main sheep population north of the reservoir. Prior to 1990, a small band of Stone's sheep in the Mount Selwyn area was the only known population south of Williston Reservoir (Churchill pers. comm. 1994).

The Peace/Williston Fish and Wildlife Compensation Program (PWFWCP) identified the Mount Frank Roy/Mount Monteith area as vacant Stone's sheep habitat suitable for a transplant project. The Mount Frank Roy/Mount Monteith transplant was proposed and conducted as one of several projects within the Williston watershed. The objectives of the Stone's Sheep transplant were to:

- establish a population of approximately 100 Stone's sheep on vacant historical range in the Mount Frank Roy/Mount Monteith area. The population target was based on biophysical capability studies (Unpub. BC Env. rep. 1989).

- identify and compare seasonal habitat use, movements and home ranges of the source and transplant sheep (Davidson 1990).

Over a 4-year period, 28 Stone's sheep, 10 of which were fitted with radio-collars, were transplanted from the north side of Williston Reservoir to the Mount Frank Roy/Mount Monteith area. Five additional animals were captured but died during or shortly after relocation. Four sheep were also radio-collared in various bands within the source herd, north of Williston Reservoir. Radio-telemetry flights were conducted from 1990 through May 1994.

2.0 STUDY AREA

The Stone's sheep project area was divided into 2 sections, the source herd area north of the Peace Arm of Williston Reservoir and the transplant area south of the Peace Arm, on the Mount Frank Roy/Mount Monteith complex (Fig. 1).

The source herd portion of the study area lies along the north side of Williston Reservoir, extending from the Nabesche River east to Butler Ridge and north to the Graham River. The entire source herd study area is within the Peace Foothills ecosection (Demarchi 1988) and is comprised of a series of north/south ridges. Elevation ranges from 670 metres along the reservoir to 1900 metres on Aylard Ridge.

The transplant portion of the study area is situated south of the Peace Arm and extends south to the Pine River, including the upper Carbon Creek and upper Moberly River watersheds. The transplant study area is situated within two ecosections: the Peace

Figure 1: Location of source herd and transplant herd study areas; 1:600,000.

Foothills, north of the Moberly River, and the Hart Foothills, south of the Moberly River. Elevation ranges from 760 metres in the major valleys to 2050 metres on Beattie Peaks.

Precipitation within both sections of the study area is variable, with the western side receiving considerably more rainfall and higher snow accumulations. The eastern side is much drier due to the increased rain shadow effect as the distance from the mountains increases. Chinook events (warm coastal winds flowing through the mountain passes into the valleys east of the Rocky Mountains) are common, resulting in windswept conditions on the eastern-most ridges and reduced snow accumulations on low-elevation southerly aspects.

Habitats in the source herd area fall into 3 biogeoclimatic zones: Alpine Tundra (AT), Engelmann Spruce-Subalpine Fir (ESSF), and Boreal White and Black Spruce (BWBS). Habitats in the transplant area fall into 4 biogeoclimatic zones: Alpine Tundra (AT), Engelmann Spruce-Subalpine Fir (ESSF), Sub-Boreal Spruce (SBS), and Boreal White and Black Spruce (BWBS).

3.0 METHODS

Methods used were the same for both the source herd and the transplant population.

3.1 Capture, Collaring, and Radio-Telemetry

Two methods were used to capture Stone's sheep for this project. Sheep in open habitats, including alpine and low elevation grassy slopes, were captured using a net gun fired from a Bell 206B helicopter. Sheep from Twenty-Mile Point[1] were captured in drive-nets. Net-gunning expertise and coordination of drive-net activities was supplied by B.C. Environment (Fort St. John). Additional assistance was provided by B.C. Environment, the Peace/Williston Fish and Wildlife Compensation Program, and local volunteers.

Sheep were transported between capture and release sites in the back seat of either a Bell 206B helicopter or A-Star 350B helicopter. All sheep moved in 1990 and 1991 were ear-tagged, while only 1 lamb was ear-tagged in 1993. Fourteen sheep were fitted with Lotek LMRT-3 radio collars, with mortality option (Lotek Engineering Ltd., Newmarket, ON): 6 in 1990, 5 in 1991 and 3 in 1993.

Collared sheep were located at monthly intervals using a fixed-wing Cessna 172 aircraft equipped with 2 wing-mounted antennae. Locations were plotted onto 1:50,000 NTS

[1] An aspen-covered bluff located between the mouths of Aylard and Adams Creeks and often, erroneously, referred to as "Rainbow Rocks". Sheer cliffs rise from the reservoir and provide escape terrain for Stone's sheep. The area historically known as Rainbow Rocks lies to the east of Twenty-Mile Point.

mapping during the flight, with additional information recorded for each location, including: time, weather conditions, specific habitat used, and counts and classifications of all animals seen. Further map details were determined from topographic maps in the office, including: Universal Transverse Mercator (UTM) grid, elevation, percent slope, and aspect. Similar information was also recorded for all incidental sightings of non-collared animals.

3.2 Seasonal Habitat Use

Seasonal habitat use was evaluated by comparing sheep use of specific vegetational associations during various times of the year. Seasonal use categories were delineated based on consistent habitat use: winter (Jan-April) includes the period of highest snow accumulation and lowest temperatures, spring (May-June) includes the lambing period and spring green-up, summer/fall (July-Oct) marks the season of greatest forage availability, while the rut (Nov-Dec) may be a period of nutritional stress for rams.

Habitat types were established by separating locations into 4 broad vegetative associations that were used consistently (Table 1). A fifth category was used to accommodate sheep sightings in other habitats, such as mineral licks and burned areas.

Table 1: Description of habitat types delineated in the Peace Arm Stone's sheep study.

Habitat type	Description
Alpine/subalpine	areas near or above treeline that support scattered stunted conifer, shrub, forb, and grass communities
Rock	large areas of rocky terrain with little or no vegetation visible from the air
Conifer bluffs	small rock bluffs surrounded by conifer timber
Shrub/grass	low deciduous vegetation with a large grass component, usually in association with steep terrain and small rock outcrops
Other	mineral licks, burns, lakes, etc.

3.3 Seasonal Movements

Three aspects of seasonal movements were considered:

- A comparison of summer versus winter range was completed by plotting all spring and summer/fall locations (May-Oct) and all rut and winter locations (Nov-April) on 1:250,000 NTS maps. Summer and winter ranges were also plotted for individual Stone's sheep.

- Spring and fall migration timing and migration distance were evaluated for Stone's sheep that showed distinctive migratory tendencies, with movements greater than 5 kilometres. Migration distances were calculated by straight line measurements from the centre of the summer range to the centre of the winter range. Migration timing was determined from locations that showed major

movement in less than 40 days. The 40-day period was arbitrarily selected as the minimum period when it might be assumed relocation flights would have occurred given that inclement weather might occasionally result in schedule disruption.

- Seasonal movements with respect to elevation were also examined. Elevations for all collared sheep locations were grouped by month and averaged.

3.4 Home Ranges

Home ranges were determined by hand-plotting all locations for individual Stone's sheep onto 1:50,000 NTS maps. Animals with less than 12 months telemetry locations were excluded from the analysis. Multi-annual minimum home range polygons were determined by connecting peripheral location points with straight lines (Mohr 1947). Home range sizes were calculated by digital planimeter.

4.0 RESULTS

4.1 Capture, Collaring, and Radio-Telemetry

During the first 2 years of the study, 3 ewes and 1 ram were captured, collared, and released in the source herd area. Between 1990 and 1993, 33 Stone's sheep were captured for transport to the Mount Frank Roy/Mount Monteith area. Three mortalities occurred in transit between the capture locations and release sites, and 2 mortalities shortly after release. Twenty-eight sheep were successfully transplanted: 6 ewes, 1 ram, and 1 male lamb 1990, 11 ewes and 3 rams in 1991, and 4 ewes and 2 female lambs in 1993.

All sheep were captured in alpine or low elevation shrub/grassland habitat (Fig. 2). Three of the 4 source herd sheep were captured in alpine habitat. Eighteen of the 28 transplant sheep were caught on low elevation winter range and 10 in alpine habitat. Release sites of transplanted Stone's sheep are shown in Figure 3. Capture and collaring results are summarized in Appendix I.

The 4 radio collars on the source herd sheep and the 10 collars on transplant population sheep were monitored on a regular basis. Locations were scheduled biweekly for the 3 months immediately after the initial transplant, and monthly for the remainder of the study. Some telemetry flights were cancelled or incomplete due to adverse weather conditions. A total of 184 radio locations were documented for sheep in the source herds. Radio location results from January 1990 through May 1994 and the final status of all collared animals are summarized in Appendix II. Telemetry data for the source herd and transplant sheep are included in Appendices III and IV, respectively.

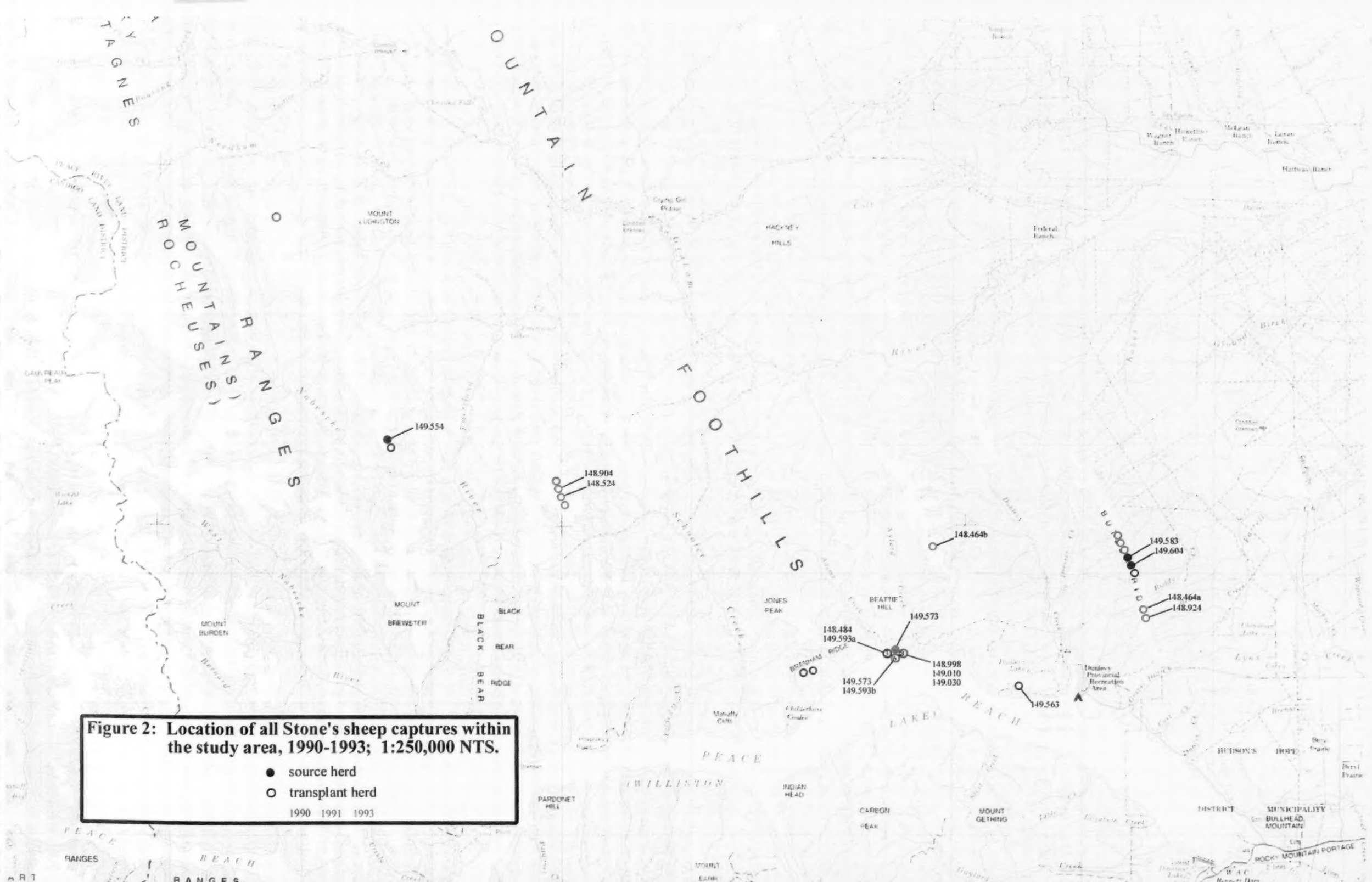

Figure 2: Location of all Stone's sheep captures within the study area, 1990-1993; 1:250,000 NTS.

- ● source herd
- ○ transplant herd

1990 1991 1993

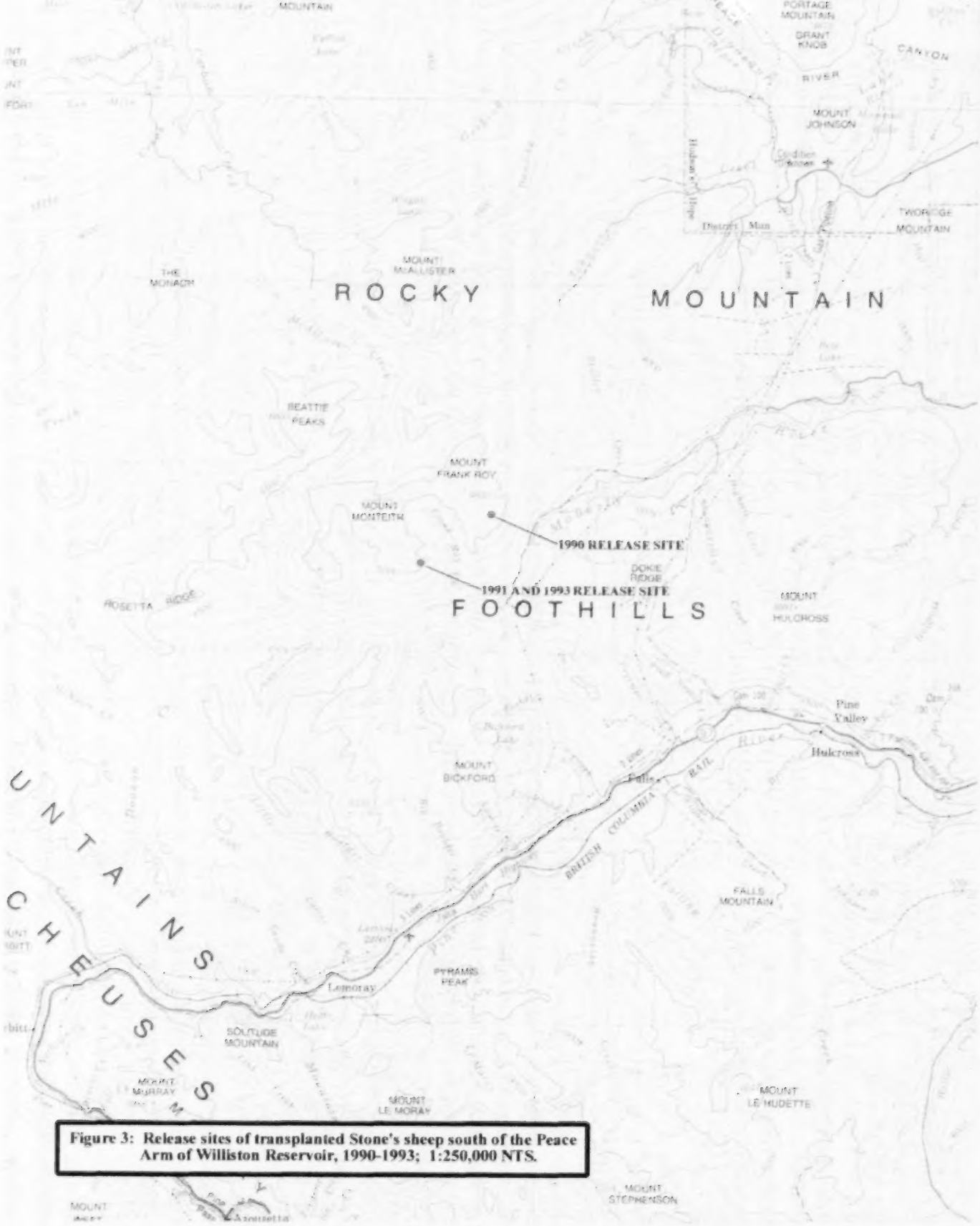

Figure 3: Release sites of transplanted Stone's sheep south of the Peace Arm of Williston Reservoir, 1990-1993; 1:250,000 NTS.

4.2 Seasonal Habitat Use

Individual seasonal habitat use data for the 4 collared sheep in the source herd is included in Appendix V. Telemetry data for the combined sample of collared animals in the source versus transplant herds is found in Appendix VI.

4.2.1 Source Herd Seasonal Habitat Use

The 4 Stone's sheep radio collared in the source herd displayed distinct variations in seasonal habitat use. Spring and summer use was comparable in that all 4 animals appeared to use a variety of available habitats, with the alpine/subalpine type being selected most frequently (Fig. 4).

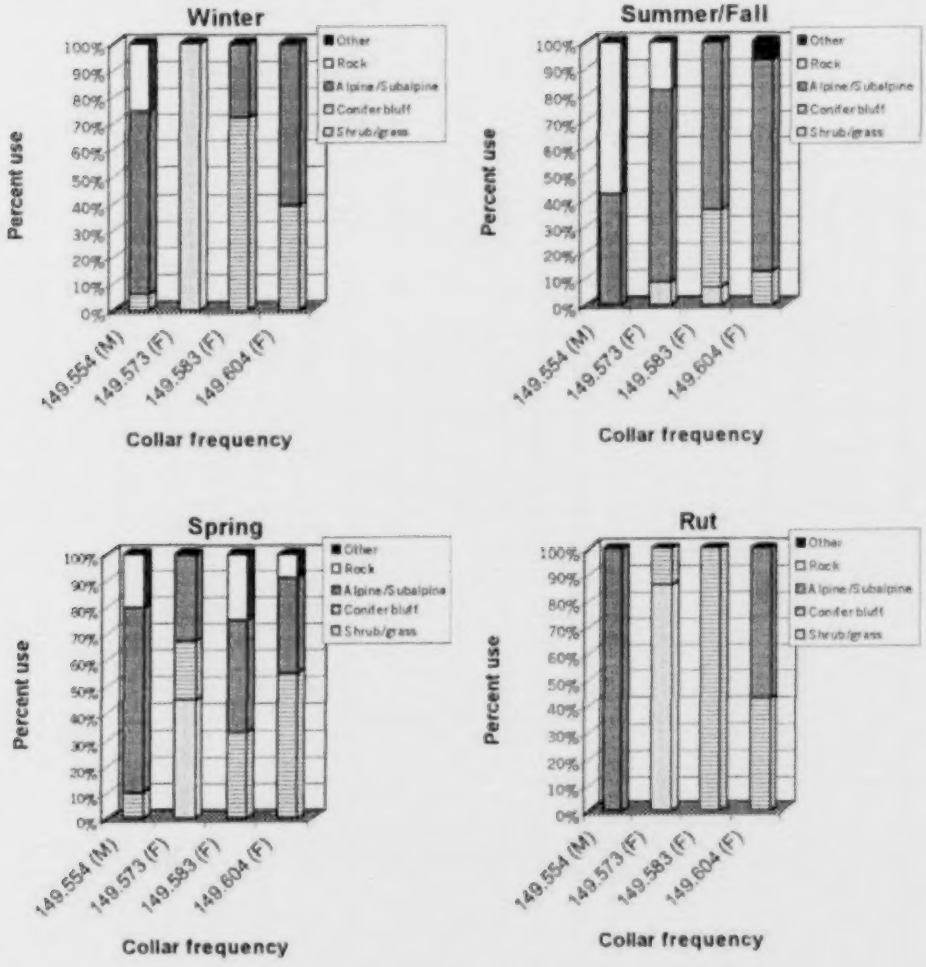

Figure 4: Seasonal habitat use of individual Stone's sheep in the Peace Arm source herd (1990-1994).

Each individual selected different habitat types during the rut, but showed a strong fidelity to that type over the course of the study. A similar situation occurred during winter, with each sheep showing a preference for a particular seasonal habitat. The low number of seasonal relocations for each animal make it difficult to draw definitive conclusions on use.

Habitat use data for the source herd has been combined to compare results from the source and transplant sheep herds (Fig. 5).

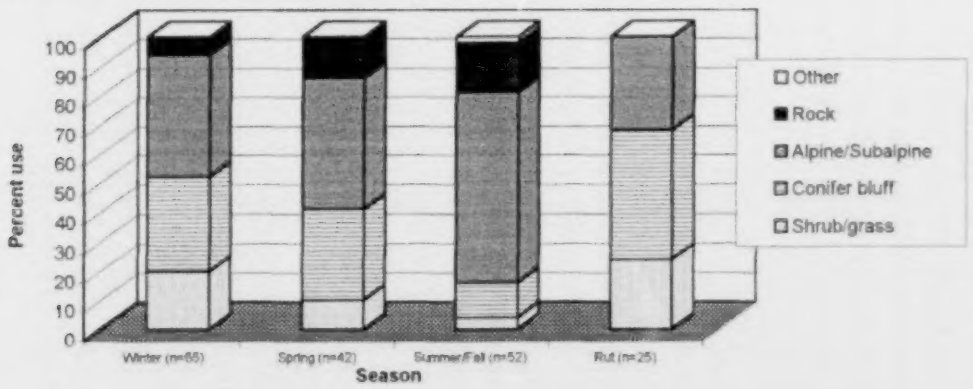

Figure 5: Seasonal habitat use of combined radio-collared Stone's sheep in the Peace Arm source herd (1990-1994).

4.2.2 Transplant Herd Seasonal Habitat Use

There were no obvious differences in habitat use by individual sheep, however, the number of locations per individual was low, ranging from 1 to 34 (mean 6.4) . Due to the limited data, radio-locations from all transplant herd sheep were combined to evaluate seasonal habitat use (Fig 6).

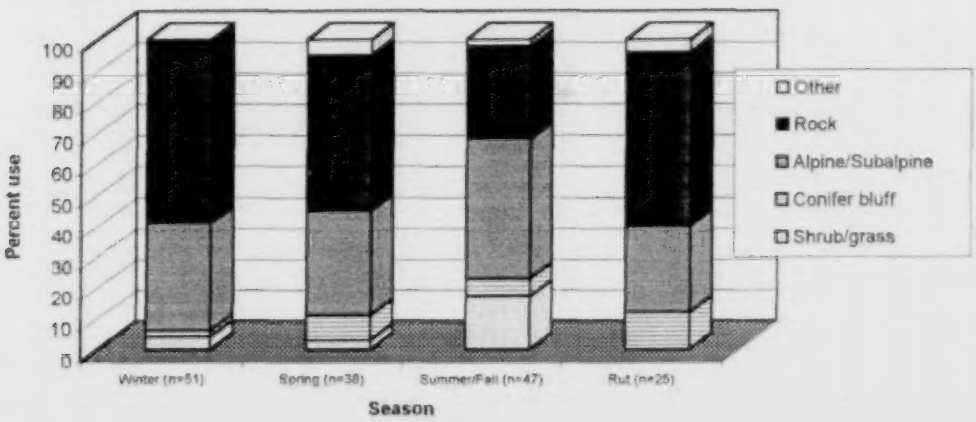

Figure 6: Seasonal habitat use of combined radio-collared Stone's sheep in the Peace Arm transplant herd (1990-1994).

4.3 Seasonal Movements

There were distinct seasonal movements made by radio-collared source herd sheep, however, no definite seasonal movement patterns were apparent in the transplant sheep.

4.3.1 Source Herd Seasonal Movements

All sheep collared in the source herd showed distinct and consistent seasonal movements. Distances between summer and winter ranges varied from 6.2 to 15 km. The ram (149.554) wintered near the south-central portion of Nabesche Ridge and summered near the north end, but usually moved to the south end during early spring. The longest movement for the animal was approximately 20 km between spring and summer ranges.

Ewes 149.573 and 149.583 summered on the north end of Aylard Ridge and were often in the same band of sheep but used distinctly separate winter ranges. Ewe 149.573 wintered near Williston Reservoir on 20-Mile Point; a distance of 13 km between seasonal ranges. Ewe 149.583 wintered on the south end of Aylard Ridge, in a complex of conifer bluffs; a movement of 7.5 km from summer range. Ewe 149.583 was originally collared on Butler Ridge but moved onto Aylard Ridge in the spring of 1990 and remained there for the duration of the study. This animal was 1.8 years at the time of capture, therefore this movement may have been the result of juvenile dispersal.

Ewe 149.604 remained on Butler Ridge throughout the year, with winter locations toward the north end and summer locations further south. This individual did not appear to have well defined seasonal ranges.

Spring movements for the ewes on Aylard Ridge occurred between mid May and the first week of June. Ewe 149.604 (Butler Ridge) made more gradual movements, with no distinct travel period. The ram tended to move onto spring range in April or early May, then to summer range in early June. Seasonal ranges of sheep collared in the source herd are shown in Figure 7.

Individuals that wintered in alpine/subalpine habitat (149.554 and 149.604) showed no distinct elevational selection over the course of the study. Individuals that consistently wintered outside of the alpine (149.573 in shrub/grassland and 149.583 on conifer bluffs) showed a shift in elevation by season. It appears that this shift is related to the availability of preferred habitats as the winter ranges selected by these individuals are not found at other elevations.

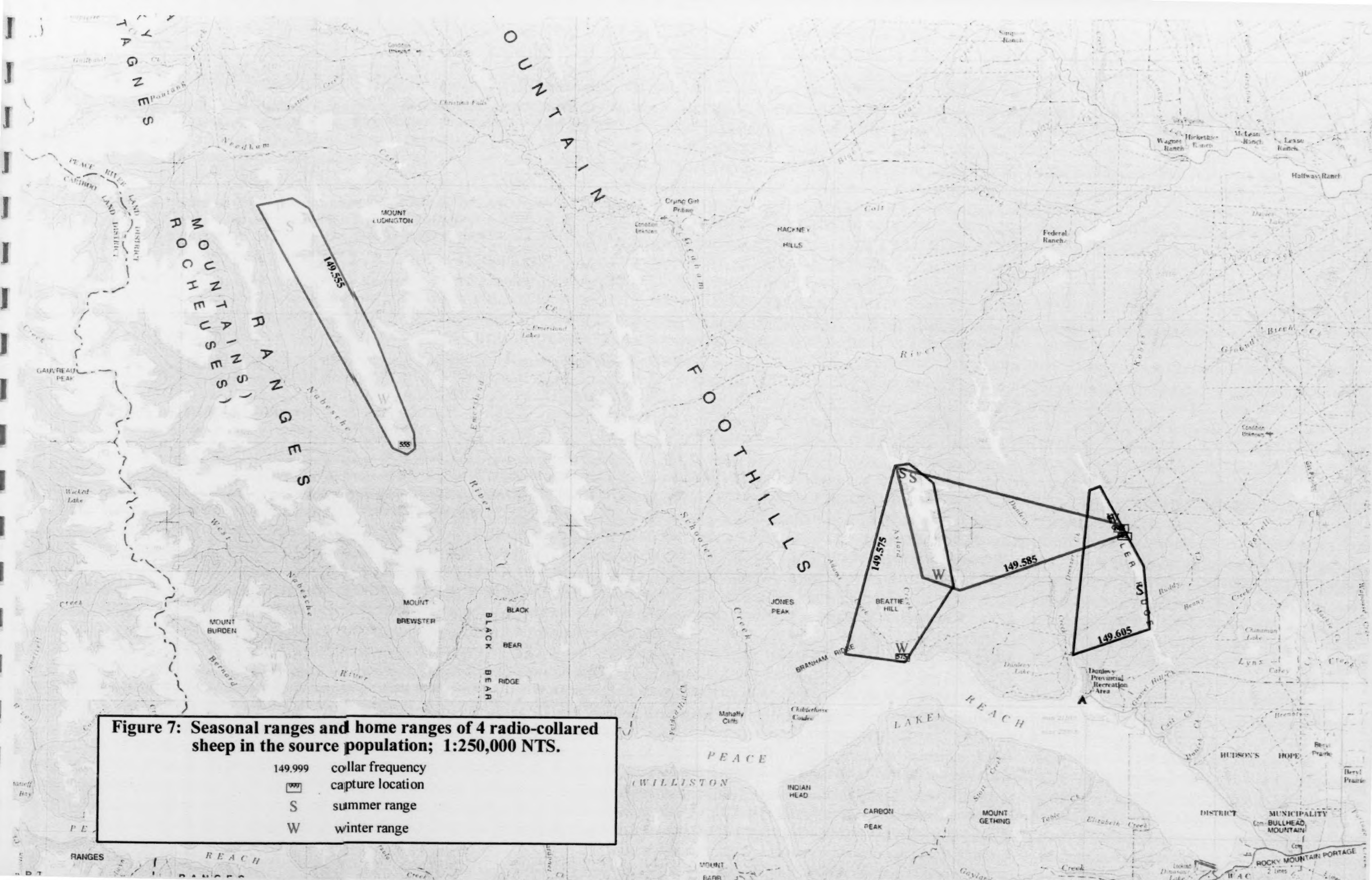

Figure 7: Seasonal ranges and home ranges of 4 radio-collared sheep in the source population; 1:250,000 NTS.

149.999 collar frequency

[999] capture location

S summer range

W winter range

4.3.2 Transplant Herd Seasonal Movements

No distinct seasonal movements were determined for Stone's sheep transplanted to the Mount Frank Roy/Mount Monteith area. Most collared sheep used a small area of escape terrain on the south face of Mount Monteith as their primary winter range. These bluffs were also used extensively in summer. Sixty-eight % of all winter locations and 41 % of all summer locations were in this area.

Winter locations were concentrated on Mount Monteith (68%), with a few on Mount Frank Roy (20%). One ewe (148.484) attempted to winter on a small set of conifer bluffs in the McAllister Creek area but did not survive. Summer locations were somewhat more dispersed, but still concentrated in the Mount Monteith and Mount Frank Roy areas (83%) with occasional locations as far as Beattie Peaks (6%), Mount McAllister (3%) and Mount Bickford (1%). Summer and winter locations are shown in Figure 8.

4.4 Home Ranges

Home range sizes of radio-collared Stone's sheep were highly variable in both the source and transplant herds.

4.4.1 Source Herd Home Ranges

Home range sizes of the source herd ranged from 43 to 132 km^2, with a mean of 75 km^2. These home ranges appear large due to each of the ewes having a few isolated locations well outside of their core range. The majority of location points for each sheep were on alpine ridges, with scattered low-elevation locations, such as at mineral licks. Ewe 149.583 was located on Butler Ridge 5 times (including capture), with 1 location at Twenty-Mile Point, and all other locations on Aylard Ridge. Although this appears to be a case of juvenile dispersal, all location data points were included in the delineation of the home range polygon.

Use of non-alpine habitat is undetermined due to the low numbers of relocations. Home ranges of source herd sheep are depicted in Figure 7.

4.4.2 Transplant Herd Home Ranges

Two of the 10 radio-collared sheep in the transplant population died less than a year after release and 1 animal was located once, then went missing. These individuals were excluded from the analysis of home range size. The remaining 7 collared sheep had extremely variable home ranges, varying from 5 to 154 km^2 (mean 59 km^2). Home ranges of the 7 sheep with at least 12 months of telemetry data are illustrated in Figure 9.

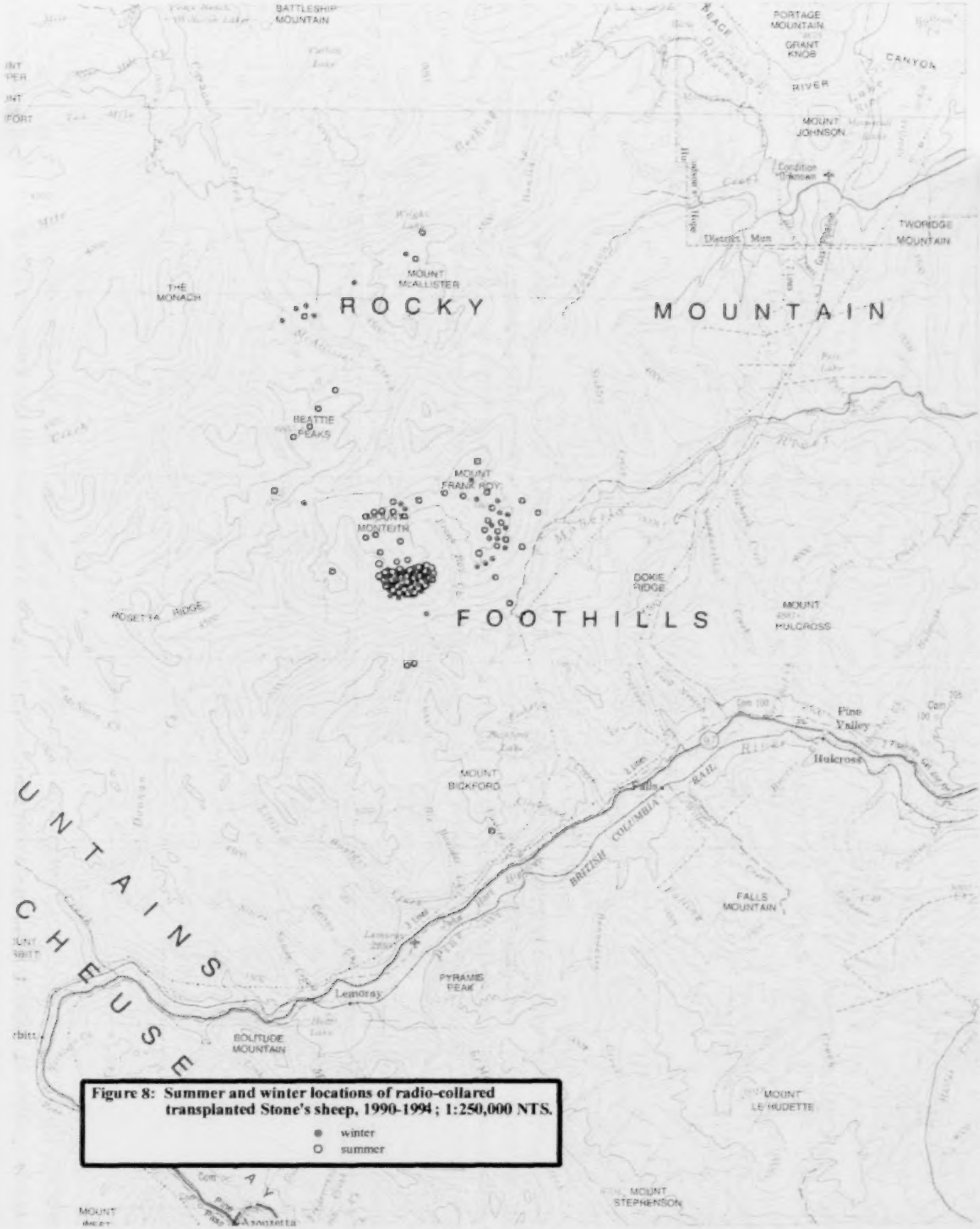

Figure 8: Summer and winter locations of radio-collared transplanted Stone's sheep, 1990-1994 ; 1:250,000 NTS.

● winter
○ summer

Figure 9: Home ranges of 7 radio-collared Stone's sheep in the transplanted population, 1990-1994; 1:250,000 NTS.

5.0 DISCUSSION

Although the transplant project objectives were partially met, with a small band of Stone's sheep established on the Mount Frank Roy/Mount Monteith complex, the viability of this population is uncertain. Only 7 sheep were recorded during a March 1995 inventory (Wood 1995). Pettus (1982) suggests a transplant population requires a minimum of 15 to 20 individuals, actively participating in breeding, to transmit the genetic diversity of the parent population. Due to the early loss of several radio-collared sheep, movements and habitat use of this band were not well-defined. Therefore, it is not known if there are any small, unlocated bands that may be contributing to genetic diversity.

Additional project objectives were to identify and compare seasonal ranges, movements, and habitat selection of the source and transplant sheep populations. Three of the 4 radio-collared sheep in the source herd survived for the entire duration of the project. The ram (149.554) was still active 1 month prior to the end of the study; the last telemetry flight found the collar transmitting a mortality signal. While these animals represent only 4 individuals in a widely dispersed population, data obtained during the study does provide some information on Stone's sheep habitat use on the Peace Arm of Williston Reservoir.

The relevance of comparing habitat selection between the collared source herd and transplant herd sheep is questionable. The source herd sheep frequently used shrub/grass habitats during the rut (24%) and winter (20%). As little of this low-elevation habitat type was available to the relocated sheep, comparison of use is misleading.

5.1 Capture, Collaring, and Radio-Telemetry

5.1.1 Capture Methods

Net guns and drive-nets were employed during the capture phase of the project. Net guns were used in the capture of 23 sheep, with 2 mortalities (8.6%). One death was the result of physical injury during netting, while the second mortality occurred during transport and was attributed to capture myopathy. Drive-nets were used in the capture of 14 sheep, with 2 mortalities (14.2%). Both deaths occurred during transport and were stress-related. Two additional sheep died shortly after being relocated. Although the cause of death is not known, transplant stress may have been a contributing factor.

A comparison of wild sheep capture techniques in Oregon shows similar results; with 5.8% mortality using drive-nets and 3.9% mortality using net guns (Lemos and Willis 1990). Lemos and Willis suggest the use of drive-nets resulted in higher stress levels and higher body temperatures due to increased pursuit time.

Chemical immobilization of Dall Sheep, for transplants in Alaska, resulted in 18% and 22% mortality (Heimer and Mauer 1990). Wild sheep capture methodology in both

Oregon and Alaska has shifted to the use of net guns due to cost effectiveness and a reduction in mortalities (Lemos and Willis 1990; Heimer and Mauer 1990).

5.1.2 Capture Timing

The timing of capture did not appear to adversely affect the results of the source herd portion of the project. All 4 sheep collared in the source population remained near the capture location immediately after release. Three of these animals had primary home ranges that included their capture locations; the fourth, a 2 year old ewe, moved from Butler Ridge to Aylard Ridge 5 months after capture, likely due to juvenile dispersal.

The timing of the transplant may have influenced the overall success of the project. All transplanted sheep were captured and moved in mid to late March. Subjecting the animals to transplant stress in late winter, when the physical condition of individual sheep would be assumed to be low, may have contributed to increased mortality. Three of the 33 sheep captured for the transplant died in transit, and another 2 died shortly after release. The cause of death of 2 of the 5 animals was believed to be capture myopathy, the third death was attributed to an injury, and the last 2 were undetermined. If the transplants had occurred in mid-winter (Dec-Jan) captured sheep may have been in better physical condition to combat stress associated with handling, transport, and adapting to a new environment.

Stress imposed on the source herd animals was limited to the initial capture, handling, and adjustment to the radio-collar. In contrast, the transplant sheep were subjected to the above factors, as well as, transport stress and the disruption of movement patterns, escape, and overwintering strategies. The loss of traditional escape terrain may be particularly significant to sheep having just experienced the rigors of capture and transport.

Moving the sheep in late March resulted in transplanted individuals being restricted to the winter habitat at the release site for only a short time. This abbreviated acclimatization period might have resulted in a more rapid dispersal as individuals sought new ranges or attempted to return to their original ranges north of Williston Reservoir.

5.2 Seasonal Habitat Use

5.2.1 Source Herd Seasonal Habitat Use

There appears to be 3 distinct wintering strategies among sheep in the source population: exposed alpine/subalpine sites (Butler Ridge to Nabesche Ridge), mid-elevation conifer bluffs (south end of Aylard Ridge), and low-elevation, south-aspect, shrub/grasslands with adjacent escape terrain (numerous sites along Williston Reservoir).

Incidental winter sightings of sheep on alpine/subalpine and shrub/grassland habitats were common during the course of the project. However, there were no sightings of sheep wintering on conifer bluffs other than the band of 7 to 9 accompanying ewe 149.583, on the south end of Aylard Ridge. There are several areas with timbered bluffs within the study area, but heavy conifer cover makes incidental sightings unlikely.

Spring habitat selection was not definitive, but sheep appeared to use alpine/subalpine habitat en route to summer range. Summer habitat use was consistently alpine/tundra and high-elevation rock. The low number of relocations of only 4 collared sheep, and the variability among individuals, prevents drawing conclusions about habitat selection during the rut.

5.2.2 Transplant Herd Habitat Use

No habitat selection was discernable from the limited data on the transplanted sheep. Alpine/subalpine and rock habitats were used extensively throughout the year: 94 % in winter, 84 % in spring, 75 % in summer and 84 % in the rut. The original evaluation of the release site habitat considered windswept alpine to be the primary winter habitat. Very little sheep habitat other than alpine is present in the area. Eighteen of the 28 successfully transplanted sheep were from low-elevation winter range in the BWBS zone along Williston Reservoir. No comparable habitat is present in the vicinity of the transplant area. The closest BWBS is at the south end of Mount Bickford, in the Pine River valley. There have been several sightings of ear-tagged sheep over the past few years in this vicinity. One collared sheep moved to this area in 1993.

Of the 7 radio-collared sheep transplanted from BWBS winter range, 1 went missing and the other 6 survived an average of 15.4 months (± 9.4). Three collared animals were transplanted from alpine winter range, with an average survival of 19.5 months (± 15.5). The small sample size prevents drawing definite conclusions, but compatibility of capture and release site habitat may be a factor in the success of the transplant. Although the selection of sheep from low elevation winter range was relatively economical, the individuals may not have been well suited to the habitat available at the release site.

5.3 Seasonal Movements

5.3.1 Source Herd Seasonal Movements

Although radio-collared source herd sheep showed individual variability in habitat selection, there were no unexpected seasonal movements. Summer ranges were typically high-elevation alpine ridges with winter range selection varying considerably. Movements between seasonal ranges were not well defined due to the low number of radio locations during the migratory periods. The timing of

migration generally coincides with seasonal climatic conditions; however, commencement may be related to specific events such as early winter storms.

5.3.2 Transplant Herd Seasonal Movements

Distinct seasonal movements were not evident in the radio-collared transplant sheep. There was a greater dispersal of locations during summer months, but no patterns were determined. Only 4 of the radio-collared transplant sheep survived for more than 2 years, and new seasonal ranges may not have been established. Chow *et al.* (1988) found that transplanted California bighorn sheep had summer and winter ranges less than 1 km apart in the first year after release, but range separation increased to 7 km in the second year. The early mortality of several of the radio-collared sheep in the transplant population resulted in inconclusive data on seasonal movements.

5.4 Home Ranges

Home ranges of Stone's sheep in both the source and transplant herds were highly variable. The only obvious difference between herds is that some of the transplanted sheep remained close to the release site. Chow (1988) found that transplanted bighorn sheep in California had very restricted home ranges in the first year after release, but ranges expanded as the sheep gained familiarity with the habitat. Although this may be true of some of the Mount Frank Roy/Mount Monteith transplant sheep, ear-tagged individuals from the original Mount Frank Roy release (1990) were reported 15 km away, in the Pine River valley, within months of release (Davidson, 1990). The results of this study do not provide conclusive evidence of any trends regarding home ranges of the radio-collared Peace Arm Stone's sheep.

6.0 RECOMMENDATIONS

Historically, wild sheep transplants have fallen short of their objectives. In Utah, 8 wild sheep reintroductions over a 22 year period (1966-1988) resulted in 2 complete failures, while the remaining 6 met with variable results (Smith *et al.* 1988).

Diverse wintering strategies identified in the parent population highlight the need for future projects to be designed to meet the requirements of specific bands. Emphasis should be placed on capturing sheep adapted to the transplant site habitat, not merely those individuals readily captured.

While the long-term results of the Mount Frank Roy/Mount Monteith transplant are undetermined, the following recommendations are designed to address the original objectives of the project and to aid in future project development.

6.1 Williston Reservoir Recommendations

- Conduct a detailed inventory of Stone's sheep on the north side of the Peace Arm of Williston Reservoir, from the Nabesche River drainage to Butler Ridge. The inventory should evaluate sheep use of the 3 habitat types identified in this study: windswept alpine/subalpine, mid-elevation conifer bluffs, and low-elevation shrub/grasslands. Fecal pellet collections should be conducted on all identified sheep winter ranges during this inventory. The analysis of winter diets of various sheep bands should be compared to the habitat available on the Mount Frank Roy/Mount Monteith complex to determine if a specific band of sheep may be best suited to winter forage availability in the transplant area.

- Develop a prescribed burning program that identifies specific Stone's sheep enhancement opportunities within each of the 3 winter range habitat types. Even if herbaceous vegetation response is not optimal, the creation of open foraging areas, without obstructing shrubs and trees, will benefit sheep through increased foraging efficiency (McWinter *et al.* 1992).

- Conduct enhancement burns on a rotational basis to increase habitat suitability of Stone's sheep range to maximum capability. McWinter *et al.* (1992) suggests the benefits of prescribed burning lasts a minimum of 15 years on bighorn sheep habitat in Wyoming. An annual rotational treatment of $1/15^{th}$ to $1/20^{th}$ of the burnable winter range is recommended.

- Continue annual winter inventories of the established Stone's sheep band on Mount Monteith to determine population trends and composition.

6.2 General Recommendations

The following recommendations are presented to aid in the planning of any future Stone's sheep transplant project:

- Conduct vegetation analysis and mapping of proposed Stone's sheep transplant range to determine existing forage composition and availability, and to evaluate the potential for winter range enhancement through prescribed burning.

- Use comparative diet analysis to insure that source herd habitat selection and foraging preferences are compatible with the proposed transplant site.

- Future transplant projects should attempt to move sheep in early to mid-winter, while individuals are still in sound physical condition and there is sufficient time, prior to snowmelt, for animals to become familiar with the new winter range.

- Due to the unpredictable habits of animals in a transplant population, all new transplants should be fitted with radio-collars and monitored intensely for the first year.

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PERSONAL COMMUNICATIONS

Churchill, B. 1994. Peace Sub-region Habitat Biologist, B.C. Environment, Fort St. John, B.C.

APPENDICES I TO VI

Appendix I: Stone's sheep capture details, 1990-1993.

Collar Frequency ▽	Capture Date	Location	Sex	Age	Ear Tags
Source Herd					
149.554	27/01/90	Nabesche Ridge	M	3.8	Green 41
149.573	16/03/91	Twenty-Mile Point	F	2.8	Red 16/14
149.583	27/01/90	Butler Ridge	F	1.8	Green 24
149.604	27/01/90	Butler Ridge	F	8.8	Green 23
Transplant Herd			*mortality in transit		
148.484	30/03/90	Adams Creek	F	8.8	Yellow 07
149.563	30/03/90	Dunlevy Creek	M	2.8	Green 26
149.593a	30/03/90	Adam Creek	F	9.8	Purple 315
N/a	30/03/90	Nabesche Ridge	F	5.8	Red 91
N/a	30/03/90	Butler Ridge	F	1.8	Red no#
N/a	30/03/90	Aylard Ridge	F	1.8	Blue no#
N/a	30/03/90	West Branham	F	1.8	White 343
N/a	30/03/90	West Branham	M	0.8	Green 30
148.524	16/03/91	Schooler/Nabesche	M	4.8	Red 25 **
148.905	15/03/91	Schooler/Nabesche	F	8.8	Red 93
148.924	15/03/91	Butler Ridge	F	1.8	Red 89 **
149.593b	15/03/91	Twenty-Mile Point	F	6.8	Red 96
N/a	15/03/91	Butler Ridge	F	9.8	Red 92
N/a	15/03/91	Butler Ridge	F	10.8	Red 97
N/a	15/03/91	Butler Ridge	F	5.8	Red 99
N/a	15/03/91	Twenty-Mile Point	F	7.8	Red 100
N/a	15/03/91	Twenty-Mile Point	F	9.8	Red 91
N/a	15/03/91	Twenty-Mile Point	F	7.8	Red 90
N/a	15/03/91	Twenty-Mile Point	F	5.8	Red 95
N/a	15/03/91	Nabesche Ridge	F	3.8	none *
N/a	16/03/91	Twenty-Mile Point	F	8.8	Red 15
N/a	16/03/91	Schooler/Nabesche	F	6.8	Red 12
N/a	16/03/91	Schooler/Nabesche	M	4.8	Red 21
148.464a	24/03/91	Butler Ridge	M	5.8	Red no#
148.464b	11/07/91	Aylard Ridge	M	5.0	none
148.998	18/03/93	Twenty-Mile Point	F	14.8	none
149.010	18/03/93	Twenty-Mile Point	F	11.8	none
149.030	18/03/93	Twenty-Mile Point	F	5.8	none
N/a	18/03/93	Twenty-Mile Point	F	5.8	none *
N/a	18/03/93	Twenty-Mile Point	F	6.8	none *
N/a	18/03/93	Twenty-Mile Point	F	lamb	none
N/a	19/03/93	Twenty-Mile Point	F	2.8	none
N/a	19/03/93	Twenty-Mile Point	F	lamb	none

* Mortality in transit

** Mortality shortly after release

▽ Collar frequencies may appear on raw data sheets as ± .002 due to frequency drift associated with temperature variation.

Appendix II: Monitoring duration and status of radio-collared Stone's sheep, 1990-1994.

Collar Frequency	Year Collared	*Last* Location	Total # of Locations	Status
Source Herd				
149.554	1990	26/05/94	42	dead 26/05/94
149.573	1991	26/05/94	40	active
149.583	1990	26/05/94	51	active
149.604	1990	26/05/94	51	active
Transplant Herd				
148.484	1990	20/02/92	22	dead
149.563	1990	25/06/91	17	dead
149.593a	1990	18/05/90	4	dead
148.464a	1991	29/05/91	3	dead
148.524	1991	16/03/91	0	dead
148.905	1991	29/04/93	30	dead
149.593b	1991	19/08/93	33	dead
148.464b	1991	08/03/94	34	dead
148.998	1993	29/04/93	1	missing
149.010	1993	08/03/94	9	dead
149.030	1993	26/05/94	11	active

Appendix III: Stone's sheep radio-locations - source herd, 1990-1994.

STONE'S SHEEP RELOCATIONS- SOURCE BANDS									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
149.604	1/27/90	Butler Ridge	5420	62344	5200	6	300	alpine	Capture location
149.604	2/13/90	Butler Ridge	5420	62344	5200	6	300	alpine	
149.604	3/5/90	Butler Ridge	5441	62294	5400	6	180	alpine	
149.604	5/18/90	Butler Ridge	5434	62309	5300	100+	250	rock	
149.604	6/8/90	Butler Ridge	5424	62280	3600	100+	180	conifer bluff	
149.604	6/28/90	Butler Ridge	5441	62306	5100	70	90	alpine	
149.604	7/14/90	Dunlevy Gorge	5390	62242	2300	20	260	mineral lick	
149.604	7/31/90	Butler Ridge	5439	62310	5200	80	70	alpine	
149.604	9/20/90	Butler Ridge	5427	62329	5200	12	270	alpine	
149.604	10/12/90	Butler Ridge	5414	62348	5200	24	90	alpine	
149.604	2/21/91	Butler Ridge	5414	62347	5300	30	180	alpine	
149.604	3/5/91	Butler Ridge	5421	62339	5300	flat	ridge	alpine	
149.604	3/19/91	Butler Ridge	5398	62371	4300	100+	270	conifer bluff	
149.604	5/2/91	Butler Ridge	5410	62349	4900	60	250	subalpine	
149.604	5/15/91	Butler Ridge	5414	62347	5200	30	180	alpine	
149.604	5/29/91	Butler Ridge	5432	62284	4200	100+	190	conifer bluff	
149.604	6/10/91	Butler Ridge	5411	62328	4200	55	180	conifer bluff	
149.604	6/28/91	Butler Ridge	5428	62298	4000	35	290	conifer bluff	
149.604	7/11/91	Butler Ridge	5426	62300	4500	100+	180	conifer bluff	
149.604	8/19/91	Butler Ridge	5441	62296	5300	30	90	alpine	
149.604	9/26/91	Butler Ridge	5443	6227	5250	20	270	alpine	
149.604	10/17/91	Butler Ridge	5439	62307	5400	flat	ridge	alpine	
149.604	10/29/91	Butler Ridge	5429	62302	4300	100+	180	conifer bluff	
149.604	11/14/91	Butler Ridge	5428	62303	4300	100+	180	conifer bluff	
149.604	11/26/91	Butler Ridge	5408	62341	4300	100+	180	conifer bluff	
149.604	12/13/91	Butler Ridge	5402	62370	4800	100+	180	alpine	
149.604	12/28/91	Butler Ridge	5409	62341	4100	100+	180	conifer bluff	
149.604	2/20/92	Butler Ridge	5402	62370	4800	100+	180	conifer bluff	
149.604	3/14/92	Butler Ridge	5404	62369	4900	flat	ridge	alpine	
149.604	4/15/92	Butler Ridge	5407	62366	5000	20	250	alpine	
149.604	5/15/92	Butler Ridge	5412	62345	4300	80	180	conifer bluff	
149.604	6/7/92	Butler Ridge	5444	62293	4900	100+	0	conifer bluff	

Appendix III: Stone's sheep radio-locations - source herd, 1990-1994. Con't.

149.604	8/1/92	Butler Ridge	5414	62348	5400	30	180	alpine	
149.604	9/30/92	Butler Ridge	5413	62347	5100	100+	210	alpine	
149.604	10/28/92	Butler Ridge	5404	62366	4700	42	260	subalpine	
149.604	11/24/92	Butler Ridge	5402	62370	4900	42	180	alpine	
149.604	1/9/93	Butler Ridge	5398	6230	4300	60	210	conifer bluff	
149.604	1/28/93	Butler Ridge	5403	62371	5000	40	210	alpine	
149.604	2/24/93	Butler Ridge	5414	62347	5200	20	180	alpine	
149.604	3/12/93	Butler Ridge	5410	62344	5050	100+	190	conifer bluff	
149.604	4/29/93	Butler Ridge	5403	62370	4900	30	180	alpine	
149.604	6/6/93	Butler Ridge	5440	62279	4900	25	300	alpine	
149.604	7/26/93	Butler Ridge	5443	6225	5400	10	270	alpine	
149.604	8/19/93	Butler Ridge	5443	62293	5200	60	80	alpine	
149.604	9/18/93	Butler Ridge	5443	62291	5000	36	90	alpine	
149.604	11/5/93	Butler Ridge	5413	62345	5000	40	180	alpine	
149.604	12/16/93	Butler Ridge	5414	62348	5200	24	180	alpine	
149.604	1/30/94	Butler Ridge	5410	62363	4700	100+	180	conifer bluff	
149.604	3/8/94	Butler Ridge	5413	62353	5300	flat	ridge	alpine	
149.604	4/28/94	Butler Ridge	5409	62344	4400	100+	180	conifer bluff	
149.604	5/26/94	Butler Ridge	5431	62301	4300	60	270	conifer bluff	Still active

Appendix III: Stone's sheep radio-locations - source herd, 1990-1994. Con't.

STONE'S SHEEP RELOCATIONS -SOURCE BANDS									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
149.554	1/27/90	Nabesche Ridge	4872	62390	4700	40	180	subalpine	Capture location
149.554	2/13/90	Nabesche Ridge	4855	62428	4900	60	360	alpine	
149.554	3/5/90	Nabesche Ridge	4877	62395	5000	80	110	conifer bluff	
149.554	5/18/90	Nabesche Ridge	4873	62394	5300	40	180	subalpine	
149.554	6/8/90	Nabesche Ridge	4875	62401	5300	70	180	alpine	
149.554	8/31/90	Nabesche Ridge	4781	62584	6500	85	270	rock	
149.554	9/20/90	Nabesche Ridge	4793	62585	6000	45	90	alpine	
149.554	10/12/90	Nabesche Ridge	4761	62581	6000	80	180	alpine	
149.554	2/21/91	Nabesche Ridge	4778	62568	7100	flat	saddle	alpine	
149.554	3/5/91	Nabesche Ridge	4812	62510	6200	flat	nil	alpine	
149.554	3/19/91	Nabesche Ridge	4791	62534	6300	40	180	alpine	
149,554	5/2/91	Nabesche Ridge	4853	62416	5800	60	210	alpine	
149.554	5/15/91	Nabesche Ridge	4847	62435	5700	55	250	rock	
149.554	5/29/91	Nabesche Ridge	4862	62398	5800	55	245	subalpine	
149.554	6/10/91	Nabesche Ridge	4863	62397	5700	42	190	conifer bluff	
149.554	6/25/91	Nabesche Ridge	4771	62575	6500	100+	10	alpine	
149.554	7/11/91	Nabesche Ridge	4783	62557	6700	100+	100	rock	
149.554	8/19/91	Nabesche Ridge	4786	62586	6500	100+	90	alpine	
149.554	9/26/91	Nabesche Ridge	4785	62542	6100	100+	20	alpine	
149.554	10/1/91	Nabesche Ridge	4771	62574	6500	100+	360	rock	
149.554	10/29/91	Nabesche Ridge	4768	62580	5900	30	30	alpine	
149.554	11/14/91	Nabesche Ridge	4769	62575	6200	30	300	alpine	
149.554	11/26/91	Nabesche Ridge	4855	62416	5900	flat	nil	alpine	
149.554	12/28/91	Nabesche Ridge	4863	62423	6100	12	ridge 4	alpine	
149.554	2/20/92	Nabesche Ridge	4845	62482	6000	12	360	alpine	
149.554	3/14/92	Nabesche Ridge	4825	62507	5600	100+	180	alpine	
149.554	4/15/92	Nabesche Ridge	4793	62529	6500	100+	20	rock	
149.554	6/8/92	Nabesche Ridge	4818	62503	6400	100+	230	rock	
149.554	8/1/92	Nabesche Ridge	4776	62564	5900	100+	320	rock	
149.554	11/24/92	Nabesche Ridge	4863	62397	5900	50	180	subalpine	
149.554	1/9/93	Nabesche Ridge	4848	62470	6100	20	170	alpine	

Appendix III: Stone's sheep radio-locations - source herd, 1990-1994. Con't.

149.554	2/24/93	Nabesche Ridge	4847	62479	6000	48	180	alpine	
149.554	3/12/93	Nabesche Ridge	4837	62465	6300	100+	170	rock	
149.554	4/29/93	Nabesche Ridge	4834	62469	5500	100+	160	rock	
149.554	6/6/93	Nabesche Ridge	4775	62566	5800	30	190	alpine	
149.554	7/26/93	Nabesche Ridge	4770	62572	6600	100+	190	rock	
149.554	8/19/93	Nabesche Ridge	4793	62528	6300	100+	200	rock	
149.554	9/18/93	Nabesche Ridge	4776	62557	6000	100+	210	rock	
149.554	1/30/94	Nabesche Ridge	4844	62480	5500	60	170	alpine	
149.554	3/8/94	Nabesche Ridge	4846	62481	6100	10	ridge	alpine	
149.554	4/28/94	Nabesche Ridge	4837	62454	6300	80	190	rock	
149.554	5/26/94	Nabesche Ridge	4868	62394	5100	60	180	subalpine	Mortality signal

Appendix III: Stone's sheep radio-locations - source herd, 1990-1994. Con't.

STONE'S SHEEP RELOCATIONS - SOURCE BANDS									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
149.573	3/15/91	Twenty-Mile Point	5254	62234	2600	12	180	A-110	Capture location
149.573	5/2/91	Aylard Ridge	5281	62297	3500	100+	210	conifer bluff	
149.573	5/15/91	Twenty-Mile Point	5253	62235	2400	30	220	shrub/grass	
149.573	5/29/91	Aylard Ridge	5292	62306	5700	24	240	alpine	
149.573	6/10/91	Branham Slide	5215	62239	3500	100+	140	shrub/grass	
149.573	6/25/91	Aylard Ridge	5267	62374	5200	12	360	alpine	
149.573	7/11/91	Aylard Ridge	5260	6237	5700	20	210	alpine	
149.573	8/19/91	Aylard Ridge	5261	62385	5600	12	360	alpine	
149.573	9/26/91	Aylard Ridge	5255	62384	5600	flat	nil	alpine	
149.573	10/17/91	Aylard Ridge	5292	62303	5600	flat	ridge	alpine	
149.573	10/29/91	Twenty-Mile Point	5253	62234	5600	40	200	shrub/grass	
149.573	11/14/91	Twenty-Mile Point	5258	62234	2300	100+	180	shrub/grass	
149.573	11/26/91	Twenty-Mile Point	5254	62234	2500	100+	190	shrub/grass	
149.573	12/13/91	Twenty-Mile Point	5251	62238	2500	36	250	shrub/grass	
149.573	12/28/91	Twenty-Mile Point	5251	62239	2400	36	220	shrub/grass	
149.573	2/3/92	Twenty-Mile Point	5254	62235	2400	35	190	shrub/grass	
149.573	2/20/92	Twenty-Mile Point	5256	62234	2500	12	180	A-110	
149.573	3/14/92	Twenty-Mile Point	5253	62235	2500	40	180	shrub/grass	
149.573	4/15/92	Twenty-Mile Point	5253	62235	2500	40	180	shrub/grass	
149.573	5/15/92	Twenty-Mile Point	5258	62235	2500	100+	180	shrub/grass	
149.573	6/7/92	Aylard Ridge	5283	62300	4000	100+	180	conifer bluff	
149.573	8/1/92	Aylard Ridge	5273	62366	5250	40	160	alpine	
149.573	9/30/92	Aylard Ridge	5275	62352	500	20	130	alpine	
149.573	10/28/92	Aylard Ridge	5292	62293	4600	36	340	rock	
149.573	11/24/92	Branham Slide	5218	62240	3500	100+	180	shrub/grass	
149.573	1/9/93	Twenty-Mile Point	5261	62236	2400	40	180	shrub/grass	
149.573	1/28/93	Twenty-Mile Point	5260	62234	2500	100+	180	shrub/grass	
149.573	2/24/93	Twenty-Mile Point	5262	62236	2400	30	140	shrub/grass	
149.573	3/12/93	Twenty-Mile Point	5253	6223	2500	30	200	shrub/grass	
149.573	4/29/93	Twenty-Mile Point	5260	62235	2600	20	140	shrub/grass	

Appendix III: Stone's sheep radio-locations - source herd, 1990-1994. Con't.

149.573	6/6/93	Twenty-Mile Point	5251	62237	2500	30	200	shrub/grass	
149.573	7/26/93	Aylard Ridge	5268	62365	5900	30	180	subalpine	
149.573	8/19/93	Aylard Ridge	5262	62363	5300	45	300	alpine	
149.573	9/18/93	Aylard Ridge	5281	62320	5100	40	250	rock	
149.573	11/5/93	Aylard Ridge	5279	62313	4900	100+	280	conifer bluff	
149.573	12/16/93	Twenty-Mile Point	5258	62233	2500	100+	180	shrub/grass	
149.573	1/30/94	Twenty-Mile Point	5260	62235	2600	100+	180	shrub/grass	
149.573	3/8/94	Twenty-Mile Point	5260	62235	2500	80	180	shrub/grass	
149.573	4/28/94	Twenty-Mile Point	5261	62235	2500	100+	180	shrub/grass	
149.573	5/26/94	Aylard Ridge	5297	62285	4500	40	270	alpine	Still active

Appendix III: Stone's sheep radio-locations - source herd, 1990-1994. Con't.

STONE'S SHEEP RELOCATIONS - SOURCE BANDS									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
149.583	1/27/90	Butler Ridge	5420	62342	5200	6	300	alpine	Capture location
149.583	2/13/90	Butler Ridge	5420	62342	5200	6	300	alpine	
149.583	3/5/90	Butler Ridge	5418	62345	5200	6	360	alpine	
149.583	5/18/90	Butler Ridge	5415	62346	5200	100+	180	rock	
149.583	6/8/90	Butler Ridge	5412	62346	5000	85	270	conifer bluff	
149.583	6/28/90	Aylard Ridge	522	62368	6250	15	90	alpine	
149.583	8/31/90	Twenty-Mile Point	5259	62234	2500	100+	180	shrub/grass	
149.583	9/20/90	Aylard Ridge	5281	62320	5100	30	240	alpine	
149.583	10/12/90	Aylard Ridge	5279	62320	4900	70	180	subalpine	
149.583	2/21/91	Aylard Ridge	527	62300	3900	100+	180	conifer bluff	
149.583	3/5/91	Aylard Ridge	526	62300	3600	100+	180	conifer bluff	
149.583	3/19/91	Aylard Ridge	5278	62299	3600	100+	180	conifer bluff	
149.583	5/2/91	Aylard Ridge	5278	62299	3600	100+	180	conifer bluff	
149.583	5/15/91	Aylard Ridge	5276	62299	3600	100+	180	conifer bluff	
149.583	5/29/91	Aylard Ridge	5264	62365	5300	36	320	alpine	
149.583	6/10/91	Aylard Ridge	5261	6230	4600	42	200	alpine	
149.583	6/25/91	Aylard Ridge	5267	6236	5400	12	360	alpine	
149.583	7/11/91	Aylard Ridge	5266	62362	5700	30	250	alpine	
149.583	8/19/91	Aylard Ridge	5269	62384	5400	18	360	alpine	
149.583	9/26/91	Aylard Ridge	5255	62384	5600	flat	nil	alpine	
149.583	10/17/91	Aylard Ridge	5262	62371	5500	48	190	alpine	
149.583	10/29/91	Aylard Ridge	5277	62300	3900	100+	180	conifer bluff	
149.583	11/14/91	Aylard Ridge	5277	62300	3900	100+	180	conifer bluff	
149.583	11/26/91	Aylard Ridge	5281	6229	3500	100+	210	conifer bluff	
149.583	12/13/91	Aylard Ridge	5277	62300	3900	100+	180	conifer bluff	
149.583	12/28/91	Aylard Ridge	5277	62300	3900	100+	180	conifer bluff	
149.583	2/3/92	Aylard Ridge	5277	62300	3900	100+	180	conifer bluff	
149.583	2/20/92	Aylard Ridge	527	62299	3800	100+	180	conifer bluff	
149.583	3/14/92	Aylard Ridge	5277	62300	3900	100+	180	conifer bluff	
149.583	4/15/92	Aylard Ridge	5273	62300	4000	100+	180	conifer bluff	

Appendix III: Stone's sheep radio-locations - source herd, 1990-1994. Con't

149.583	5/15/92	Aylard Ridge	5293	62296	4900	42	270	rock	
149.583	6/7/92	Aylard Ridge	5264	62368	5100	60	200	rock	
149.583	8/1/92	Aylard Ridge	5273	62366	5250	40	160	alpine	
149.583	9/30/92	Aylard Ridge	5277	62300	3900	100+	180	conifer bluff	
149.583	10/28/92	Aylard Ridge	5275	62301	3900	100+	180	conifer bluff	
149.583	11/24/93	Aylard Ridge	5277	62301	3900	100+	180	conifer bluff	
149.583	1/9/93	Aylard Ridge	5276	62300	3900	100+	180	conifer bluff	
149.583	1/28/93	Aylard Ridge	5278	62312	4800	100+	270	conifer bluff	
149.583	2/24/93	Aylard Ridge	5281	62320	5100	36	210	subalpine	
149.583	3/12/93	Aylard Ridge	5276	62300	3900	100+	180	conifer bluff	
149.583	4/29/93	Aylard Ridge	5294	62303	5000	20	210	alpine	
149.583	6/6/93	Aylard Ridge	5264	6230	5600	20	190	alpine	
149.583	7/26/93	Aylard Ridge	5267	62365	5900	30	180	subalpine	
149.583	8/19/93	Aylard Ridge	5274	62381	5600	12	120	alpine	
149.583	9/18/93	Aylard Ridge	5281	62320	5100	40	250	conifer bluff	
149.583	11/5/93	Aylard Ridge	5279	62313	4900	100+	280	conifer bluff	
149.583	12/16/94	Aylard Ridge	5270	62322	4100	100+	180	conifer bluff	
149.583	1/30/94	Aylard Ridge	5274	62318	4500	100+	180	conifer bluff	
149.583	3/8/94	Aylard Ridge	5273	62309	4000	100+	180	conifer bluff	
149.583	4/28/94	Aylard Ridge	5279	62310	4800	70	180	conifer bluff	
149.583	5/26/94	Aylard Ridge	5290	62280	3900	50	260	conifer bluff	Still active

Appendix IV: Stone's sheep radio-locations - transplant herd, 1990-1994.

STONE'S SHEEP RELOCATIONS - MOUNT FRANK ROY TRANSPLANT									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
148.484	3/30/90	Mt. Frank Roy	5361	61758	5200	flat	ridge	alpine	Release site
148.484	4/6/90	Mt. Frank Roy	5374	61795	4600	20	50	alpine	
148.484	4/13/90	Mt. Frank Roy	5359	61805	5900	36	180	alpine	
148.484	5/1/90	McAllister Creek	5272	61887	3300	100+	180	conifer bluff	
148.484	6/8/90	Mt. McAllister	5326	61933	5400	70	180	alpine	
148.484	6/28/90	Beattie Peaks	5283	61842	5600	6	360	alpine	
148.484	7/31/90	Beattie Peaks	5275	61836	5700	20	90	alpine	
148.484	8/19/90	Beattie Peaks	5271	61830	6400	60	360	alpine	
148.484	9/20/90	Mt. Monteith	5324	61785	5700	36	270	alpine	
148.484	10/12/90	Mt. Frank Roy	5392	61828	4000	flat	nil	logged	
148.484	6/10/91	Mt. Frank Roy	5383	61789	4400	36	160	alpine	
148.484	6/25/91	Mt. Frank Roy	5365	61775	6200	100+	30	alpine	
148.484	7/11/91	Mt. Monteith	5323	61750	5900	100+	180	alpine	
148.484	8/19/91	Mt. Monteith	5312	61778	6500	100+	360	rock	
148.484	9/26/91	Mt. Frank Roy	5362	61792	6400	40	360	alpine	
148.484	10/17/91	Mt. Frank Roy	5362	61760	5200	flat	ridge	NSR burn	
148.484	10/29/91	Mt. Monteith	5330	61736	4000	100+	170	conifer bluff	
148.484	11/14/91	Carbon Creek	5256	61876	4200	20	10	Pl(Sw)-822	
148.484	11/26/91	McAllister Creek	5271	61887	3400	100+	210	conifer bluff	
148.484	12/13/91	McAllister Creek	5269	61889	3100	100+	180	conifer bluff	
148.484	12/28/91	McAllister Creek	5273	61887	3500	100+	180	conifer bluff	
148.484	2/20/92	McAllister Creek	5292	61901	4700	45	130	conifer bluff	Mortality signal

Appendix IV: Stone's sheep radio-locations - transplant herd, 1990-1994 - Con't.

STONE'S SHEEP RELOCATIONS MOUNT FRANK ROY TRANSPLANT									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
149.563	3/30/90	Mt. Frank Roy	5366	61756	5100	6	270	alpine	Release site
149.563	4/6/90	Mt. Frank Roy	5362	61748	4500	36	180	NSR burn	
149.563	4/13/90	Mt. Monteith	5340	61737	4200	12	180	alpine	
149.563	5/18/90	Mt. Monteith	5338	61737	4400	80	180	rock	
149.563	6/8/90	Mt. Monteith	5344	61739	41000	80	180	rock	
149.563	6/28/90	Mt. Frank Roy	5372	61745	5000	40	180	alpine	
149.563	7/31/90	Mt. Frank Roy	5364	61767	3600	70	160	pine	
149.563	9/20/90	Mt. Monteith	5340	61440	3700	80	180	rock	
149.563	10/12/90	Mt. Monteith	5340	61732	3900	100+	180	rock	
149.563	2/21/91	Mt. Monteith	5334	61734	4500	100+	180	rock	
149.563	3/5/91	Mt. Monteith	5333	61738	4100	100+	180	rock	
149.563	3/19/91	Mt. Monteith	5333	61737	4300	100+	180	rock	
149.563	5/2/91	Moberly River	5330	61701	3300	75	360	conifer bluff	
149.563	5/15/91	Mt. Monteith	5334	61737	4100	48	190	rock	
149.563	5/29/91	Mt. Frank Roy	5384	61751	3700	48	90	A/Pl-110	
149.563	6/10/91	Mt. Monteith	5336	61737	4300	100+	180	rock	
149.563	6/25/91	Moberly River	5379	61729	2800	nil	nil	river	Dead in river

Appendix IV: Stone's sheep radio-locations - transplant herd, 1990-1994-Con't.

STONE'S SHEEP RELOCATIONS-MOUNT FRANK ROY TRANSPLANT									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
149.593a	3/31/90	Mt. Frank Roy	5363	61756	5300	6	90	alpine	Release site
149.593a	4/6/90	Mt. Frank Roy	5362	61748	4500	36	180	NSR burn	
149.593a	4/13/90	Mt. Monteith	5341	61735	4000	36	140	alpine	
149.593a	5/18/90	Mt. Frank Roy	5359	61802	5600	40	170	alpine	Mortality signal

STONE'S SHEEP RELOCATIONS - MOUNT FRANK ROY TRANSPLANT									
Frequency	**Date**	**Location**	**Easting**	**Northing j**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
148.464a	5/2/91	Mt. Monteith	5316	61748	5800	48	180	alpine	Release site
148.464a	5/15/91	Mt. Monteith	5327	61739	5000	60	135	rock	
148.464a	5/29/91	Moberly River	5345	61722	2800	nil	nil	river	Dead in river

STONE'S SHEEP RELOCATIONS - MOUNT FRANK ROY TRANSPLANT									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**% Slope**	**Aspect**	**Forest Cover**	**Comments**
148.464b	7/11/91	Mt. Frank Roy	5341	61790	5500	15	180	alpine	Release site
148.464b	8/19/91	Mt. Monteith	5312	61778	6500	100+	360	rock	
148.464b	9/26/91	Mt. Monteith	5304	61772	6300	40	280	alpine	
148.464b	10/17/91	Mt. Monteith	5338	61740	4900	60	180	NSR burn	
148.464b	10/29/91	Mt. Monteith	5330	61736	4000	100+	170	conifer bluff	
148.464b	11/14/91	Mt. Frank Roy	5270	61783	5300	35	110	alpine	
148.464b	11/26/91	Mt. Frank Roy	5379	61776	5000	20	160	alpine	
148.464b	12/13/91	Mt. Frank Roy	5369	61782	5200	20	180	alpine	
148.464b	12/28/91	Mt. Frank Roy	5369	61775	6100	40	90	alpine	
148.464b	2/3/92	Mt. Frank Roy	5371	61774	5800	30	190	alpine	
148.464b	2/20/92	Mt. Frank Roy	5371	61772	5900	12	140	alpine	
148.464b	3/14/92	Mt. Frank Roy	5362	61788	6500	40	100	alpine	
148.464b	4/15/92	Mt. Monteith	5330	61743	5100	100+	180	rock	
148.464b	5/15/92	Mt. Monteith	5331	61743	5000	100+	180	rock	
148.464b	6/7/92	Mt. Frank Roy	5379	61783	4900	24	70	alpine	
148.464b	8/1/92	Mt. Frank Roy	5370	61770	6100	45	160	alpine	

Appendix IV: Stone's sheep radio-locations - transplant herd, 1990-1994 - Con't.

148.464b	9/30/92	Mt. Frank Roy	5371	61772	5900	36	100	alpine	
148.464b	10/28/92	Mt. Monteith	5333	61744	5600	18	100	alpine	
148.464b	11/24/92	Mt. Monteith	5330	61740	4900	100+	180	rock	
148.464b	1/9/93	Mt. Monteith	5331	61741	4800	100+	180	rock	
148.464b	1/28/93	Mt. Monteith	5334	61743	5400	100+	180	rock	
148.464b	2/24/93	Mt. Monteith	5331	61745	5500	100+	180	rock	
148.464b	3/12/93	Mt. Monteith	5332	61740	4900	100+	180	rock	
148.464b	4/29/93	Mt. Monteith	5313	61750	5500	40	270	rock	
148.464b	6/6/93	Mt. Monteith	5338	6143	5200	40	120	alpine	
148.464b	7/26/93	Beattie Peaks	5251	61792	5800	flat	nil	alpine	
148.464b	8/19/93	Mt. Frank Roy	5365	61792	6200	36	45	alpine	
148.464b	9/18/93	Mt. McAllister	5322	61920	500	50	110	rock	
148.464b	11/5/93	Mt. McAllister	5323	61920	500	40	100	alpine	
148.464b	12/16/93	Mt. Monteith	5330	61740	5300	100+	180	rock	
148.464b	1/30/94	Mt. Monteith	5340	61740	5400	40	120	alpine	
148.464b	3/8/94	Mt. Monteith	5339	61752	5500	40	40	rock	Mortality signal

STONE'S SHEEP RELOCATIONS - MOUNT FRANK ROY TRANSPLANT

Frequency	Date	Location	Easting	Northing	Elevation	% Slope	Aspect	Forest Cover	Comments
149.593b	3/19/91	Mt. Monteith	5330	61739	4800	100+	180	rock	Release site
149.593b	5/2/91	Moberly River	5328	61701	3300	5	90	conifer bluff	
149.593b	5/15/91	Mt. Monteith	5327	61737	4300	60	130	rock	
149.593b	5/29/91	Mt. Monteith	5332	61742	5000	60	180	rock	
149.593b	6/10/91	Mt. Monteith	5312	61744	5400	24	190	alpine	
149.593b	6/25/91	Mt. Monteith	5309	61732	4100	15	210	rock ridge	
149.593b	7/11/91	Moberly River	5281	61746	5400	40	180	rock ridge	
149.593b	8/19/91	Mt. Monteith	5322	61750	5700	12	280	alpine	
149.593b	9/26/91	Mt. Monteith	5301	61783	5900	30	180	alpine	

Appendix IV: Stone's sheep radio-locations - transplant herd, 1990-1994 - Con't.

149.593b	10/17/91	Mt. Monteith	5338	61740	4900	60	180	NSR burn	
149.593b	10/29/91	Mt. Monteith	5328	61736	4000	50	180	NSR burn	
149.593b	11/14/91	Mt. Monteith	5530	61738	4400	100+	180	rock	
149.593b	11/26/91	Mt. Monteith	5330	61743	5400	100+	180	rock	
149.593b	12/13/91	Mt. Monteith	5334	61740	4800	100+	180	alpine	
149.593b	12/28/91	Mt. Monteith	5335	61737	4500	100+	180	rock	
149.593b	2/20/92	Mt. Monteith	5330	61741	4900	100+	180	rock	
149.593b	3/14/92	Mt. Monteith	5332	61746	5700	12	150	alpine	
149.593b	4/15/92	Mt. Monteith	5336	61740	4900	100+	180	rock	
149.593b	5/15/92	Mt. Monteith	5334	61742	5000	100+	180	rock	
149.593b	6/7/92	Mt. Monteith	5333	61740	5000	100+	180	rock	
149.593b	8/1/92	Mt. Frank Roy	5329	61741	5200	100+	180	rock	
149.593b	9/30/92	Mt. Frank Roy	5370	61770	6100	45	160	alpine	
149.593b	10/28/92	Mt. Monteith	5332	61743	5400	100+	180	rock	
149.593b	11/24/92	Mt. Monteith	5329	61740	4800	100+	180	rock	
149.593b	1/9/93	Mt. Monteith	5330	61739	4900	100+	180	rock	
149.593b	1/28/93	Mt. Monteith	5331	61741	4800	100+	180	rock	
149.593b	2/24/93	Mt. Monteith	5334	61743	5400	100+	180	rock	
149.593b	3/12/93	Mt. Monteith	5331	61745	5500	100+	180	rock	
149.593b	4/29/93	Mt. Monteith	5328	61739	5000	100+	180	rock	
149.593b	6/6/93	Mt. Monteith	5328	61742	5000	100+	180	rock	
149.593b	7/26/93	Mt. Monteith	5327	61743	5300	100+	180	rock	
149.593b	8/19/93	Coyote Creek	5382	61597	3400	100+	200	rock	Mortality signal

STONE'S SHEEP RELOCATIONS - MOUNT FRANK ROY TRANSPLANT									
Frequency	**Date**	**Location**	**Easting**	**Northing**	**Elevation**	**%Slope**	**Aspect**	**Forest Cover**	**Comments**
148.905	3/19/91	Mt. Monteith	5326	61736	4600	100+	140	rock	Release site
148.905	5/2/91	Mt. Monteith	5336	61738	4400	75	180	rock	
148.905	5/15/91	Mt. Monteith	5323	61736	54800	36	140	rock	
148.905	5/29/91	Mt. Monteith	5326	61739	5000	100+	140	rock	
148.905	6/10/91	Mt. Motet	5328	61738	4400	100+	120	rock	
148.905	6/25/91	Mt. Monteith	5332	61744	5700	20	180	alpine	
148.905	7/11/91	Mt. Monteith	5323	61750	5900	100+	180	alpine	

Appendix IV: Stone's sheep radio-locations - transplant herd, 1990-1994 - Con't.

148.905	8/19/91	Mt. Monteith	5312	61778	6500	100+	360	rock	
148.905	9/26/91	Mt. Monteith	5304	61772	6300	40	280	alpine	
148.905	10/17/91	Mt. Monteith	5338	61740	4900	60	180	NSR burn	
148.905	10/29/91	Mt. Monteith	5331	61738	4000	50	170	NSR burn	
148.905	11/14/91	Mt. Monteith	5330	61738	4400	100+	180	rock	
148.905	11/26/91	Mt. Monteith	5330	61743	5400	100+	180	rock	
148.905	12/13/91	Mt. Monteith	5334	61740	4800	100+	180	alpine	
148.905	12/28/91	Mt. Monteith	5335	61737	4500	100+	180	rock	
148.905	2/3/92	Mt. Monteith	5331	61741	5000	100+	180	rock	
148.905	2/20/92	Mt. Monteith	5333	61745	5600	18	150	alpine	
148.905	3/14/92	Mt. Monteith	5335	61741	4900	100+	180	rock	
148.905	4/15/92	Mt. Monteith	5334	61742	5000	100+	180	rock	
148.905	5/15/92	Mt. Monteith	5330	61742	5000	100+	180	rock	
148.905	6/7/92	Mt. Monteith	5335	61747	5700	30	140	alpine	
148.905	8/1/92	Mt. Frank Roy	5370	61770	6100	45	160	alpine	
148.905	9/30/92	Mt. Frank Roy	5371	61772	5900	36	100	alpine	
148.905	10/28/92	Mt. Monteith	5331	61740	4900	100+	180	rock	
148.905	11/24/92	Mt. Monteith	5331	61740	4900	100+	180	rock	
148.905	1/9/93	Mt. Monteith	5331	61741	4800	100+	180	rock	
148.905	1/28/93	Mt. Monteith	5334	61743	5400	100+	180	rock	
148.905	2/24/93	Mt. Monteith	5331	61745	5500	100+	180	rock	
148.905	3/12/93	Mt. Monteith	5330	61739	4900	100+	180	rock	
148.905	4/29/93	Mt. Monteith	5333	61741	4800	100+	180	rock	Mortality signal

Appendix V: Individual Stone's sheep seasonal habitat use data - source herd, 1990-1994.

Season	Sheep #	Sex	Capture Location	n	Shrub/ grass	Conifer bluff	Alpine/ Subalpine	Rock	Other
Winter	149.554	M	Nabesche	16	0	6	69	25	0
	149.573	F	20-Mile Pnt	13	100	0	0	0	0
	149.583	F	Butler R.	18	0	72	28	0	0
	149.604	F	Butler R.	18	0	39	61	0	0
Spring	149.554	M	Nabesche	10	0	10	70	20	0
	149.573	F	20-Mile Pnt	9	45	22	33	0	0
	149.583	F	Butler R.	12	0	33	42	25	0
	149.604	F	Butler R.	11	0	55	36	9	0
Summer/Fall	149.554	M	Nabesche	12	0	0	42	58	0
	149.573	F	20-Mile Pnt	11	9	0	73	18	0
	149.583	F	Butler R.	14	7	29	64	0	0
	149.604	F	Butler R.	15	0	13	80	0	7
Rut	149.554	M	Nabesche	4	0	0	100	0	0
	149.573	F	20-Mile Pnt	7	86	14	0	0	0
	149.583	F	Butler R.	7	0	100	0	0	0
	149.604	F	Butler R.	7	0	43	57	0	0

Appendix VI: Combined Stone's sheep habitat use data - source and transplant herds, 1990-1994

Season	n	Shrub/grass	Conifer bluff	Alpine/Subalpine	Rock	Other
Source Herd						
Winter	65	20	32	42	6	0
Spring	42	10	31	45	14	0
Summer/Fall	52	4	12	65	17	2
Rut	25	24	44	32	0	0
Transplant Herd						
Winter	51	4	2	35	59	0
Spring	38	3	8	34	50	5
Summer/Fall	47	17	6	45	30	2
Rut	25	0	12	28	56	4